Financial Performance of New England Dairy Farms

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This article uses a procedure developed by Melichar to classify 124 New England dairy farms according to their financial performance. Logit regression is then used to estimate a model that seeks to explain the variation in observed financial performance. It was found that 80% of the farms in the sample were in good financial position in 1984. The results of the logit regression suggest that production per cow, farm operating expense per cow, milk price, non-milk sources of farm income, farm size, farm location, and land purchases in the last five-year period are statistically significant determinants of financial performance. Surprisingly, operator education is not statistically significant.

It is well known that many agricultural producers experienced financial difficulties in the mid-1980s. According to Melichar,[1] 17% of the nation's farmers were showing signs of financial stress in 1985; and, although this has been a national problem, producers of some commodities have been more vulnerable than others. For instance, Gabriel[2] found that, except for poultry production, dairy farmers have experienced more financial difficulty than producers of other agricultural commodities. The size and importance of the nation's dairy industry underscore the seriousness of the financial stress problem in this sector. For example, in

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1984 cash receipts from marketings of dairy products amounted to 17.9 billion dollars or 12.6% of the total US cash farm receipts.[3] Some government programs, designed to diminish the imbalance between the supply of and the demand for milk and milk products (e.g., The Dairy Product Stabilization Act of 1983), compounded an already precarious financial situation. The financial position of dairy farms can be expected to remain an important issue given that technology, market conditions, and government policies are changing rapidly. In this environment, it is critical that participants in the dairy sector have a good understanding of the major determinants of farm financial performance.

Several recent studies have addressed the financial stress issue of dairy farmers in various regions of the nation. This work includes the analyses by Thurston, Criner, and Reeb[4] for Maine; Gineo, Bravo-Ureta, and Wadsworth[5] for New England; Grisley[6] for Pennsylvania; Kauffman and Tauer[7] for New York; Carley and Fletcher[8] for three Southern states; Adelaja and Rose[9] for New Jersey; and Lines and Morehart,[10] and Baum, Morehart, and Johnson[11] for various regions in the United States. A shortcoming of some of these studies is the reliance on single financial ratios as an indicator of financial performance (e.g., residual cash flow, debt per cow). Although most of these studies provide useful information on the magnitude of financial stress in dairy farming, the papers by Kauffman and Tauer,[7] Carley and Fletcher,[8] and Adelaja and Rose[9] are the only ones that examine the determinants of financial performance.

In this study data for a sample of New England dairy farms, where dairying accounted for 37% of total cash farm receipts in 1984,[12] are used to pursue two specific objectives: (a) individual operations are classified according to their financial performance using a multidimensional measure developed by Melichar[1]; and (b) a logit regression model is estimated to examine the determinants of financial performance.

DATA AND FINANCIAL CLASSIFICATION

The main data source for this article is a sample of individual New England dairy farmers cooperating in the Electronic Farm Accounts (ELFAC) program.* ELFAC membership does not constitute a random sample of the larger population of New England dairy farmers; hence, inferences to the larger population cannot be made with statistical precision. However, data originating from farm record services, such as ELFAC, can be obtained at reasonable cost and tend to be more accurate than data collected from a random survey because of field agent supervision.[13]

The specific data used are based on individual dairy farm records from a total of 212 operations for the calendar year 1984. In order to obtain socioeconomic and additional technical data not available from ELFAC records, a survey was sent to these 212 producers; 152 responded, yielding a 71.6% response rate. The farms appearing in both the 1984 ELFAC and survey data were merged with a 1983 ELFAC data set which was needed for econometric estimation, as discussed below. This process yielded a total of 124 farms for the analysis.

Melichar's[1] procedure, used in this study to determine a farm's financial

*ELFAC is a management educational program for farms designed to improve management and to increase earnings. The organization is sponsored by the individual Extension Services in the Northeastern United States.

Table 1. Descriptive Statistics for the Variables Used in the Financial Position Classification.

Variable[a]	Mean	Standard Deviation
Debt-to-Asset Ratio (%)	21.6	23.5
Return on Assets (%)	8.3	8.0
Return on Equity (%)	8.6	12.9
Equity ($)	285,702	179,657
Sample Size	124	

[a] Variables are defined in the text.

position, combines debt-to-asset ratio, return on assets, return on equity, and equity level to classify farms into four financial position categories: (1) good; (2) fair; (3) stressed; and (4) vulnerable (see Appendix for details). According to Melichar,[1] farms classified as vulnerable are currently experiencing financial trouble and may not survive, while those in the stressed group are heading for trouble unless returns improve. Farms classified as fair may not be able to sustain their equity or fully service debt in the long term, but they are not in serious trouble presently; and those falling in the good position are not experiencing financial stress.

The definitions of the financial ratios needed to implement Melichar's[1] scheme are as follows:

D/A = Debt-to-asset ratio equal to total debt as a percentage of total farm assets.
ROA = Return on assets equal to net farm income before interest payments minus the value of unpaid labor as a percentage of total farm assets.†
ROE = Return on equity equal to net farm income minus the value of unpaid labor and interest payments as a percentage of equity.
Equity = Total farm assets minus debt.

Table I presents descriptive statistics for the variables used in the financial position classification. The average D/A, ROA, and ROE ratios computed for the farms in the sample are 21.6, 8.3, and 8.6%, respectively. The average farm in the sample has $285,702 in equity.

Table II provides the financial performance positions of the 124 dairy farms in the sample. For comparison purposes, the positions of the 212 farms in the 1984 ELFAC data set are also given. Of the 124 farms, 99 (79.8%) fall in the good financial position, 13 (10.5%) in the fair, 5 (4.0%) in the stressed, and the remaining 7 farms (5.7%) are classified as vulnerable. The results of the finan-

†It should be noted that net farm income is not on a full accrual basis because depreciation could not be included in the calculations due to data limitations. Excluding depreciation may impact on the measurement of net farm income and financial ratios. To minimize the effect of this common data limitation, Melichar[1] specified relatively high rates of return on assets and equity when developing the classification system. For further details on this issue, the interested reader is referred to Lins, Ellinger, and Lattz.[14]

Table II. Financial Position Classification Based on Melichar's Criteria for Selected New England Dairy Farms, 1984.

Financial Position	Sample Used in Study		ELFAC Data Set	
	No. Farms	Percentage[a]	No. Farms	Percentage
Good	99	79.8	166	78.4
Fair	13	10.5	20	9.4
Stressed	5	4.0	13	6.1
Vulnerable	7	5.7	13	6.1
Total	124	100.0	212	100.0

[a] Based on a chi-square test, the hypothesis that the distribution of financial performance from the two samples is the same cannot be rejected at the 0.01 level of significance.

cial position classification for these sample farms are quite similar to those obtained for the larger 1984 ELFAC data set. In fact, based on a chi-square test,[15] the hypothesis that the distribution of financial performance from the two samples is the same cannot be rejected at the 0.01 level of significance. From this point on, the analysis is based solely on the sample of 124 farms.

MODEL SPECIFICATION

As indicated earlier, a regression model is formulated to investigate the determinants of financial performance. The dependent variable is qualitative in nature and is based on the financial performance position derived from Melichar's[1] classification scheme. For each farm in the sample, the dependent variable is assigned a value of 3, 2, 1, or 0 if the farm is classified as good, fair, stressed, or vulnerable, respectively. The model is formulated as a polychotomous ordered-response model[16] and is estimated using the LOGIST procedure in SAS.[17] The equation to be estimated can be written as:

$$P_{ij} = 1/[1 + \exp(-Z)], \tag{1}$$

where P_{ij} = the probability that financial performance, the dependent variable, for the ith farm is $\geq j$, and j is equal to 1, 2 or 3 if the farm is classified as stressed, fair or good, respectively; $Z = a_j + B_1\text{PROCOW} + B_2\text{EXCOW} + B_3\text{MILKPRICE} + B_4\text{GRMPCT} + B_5\text{COW} + B_6\text{COWSQ} + B_7\text{AGE} + B_8\text{AGESQ} + B_9\text{LAND} + B_{10}\text{CTMA} + B_{11}\text{VT} + B_{12}\text{NH} + B_{13}\text{EDUC1} + B_{14}\text{EDUC2}$; exp = base of the natural logarithm; a_j = intercept term, (j = 1,2,3); and B_k = estimated parameters, (k = 1,2,...14).

The variables included in Eq. (Z) are defined as follows: PROCOW is milk production per cow; EXCOW is total farm operating expenses per cow; MILKPRICE is the price received per hundredweight of milk adjusted to a 3.5% butterfat basis; GRMPCT is the gross return from milk as a percentage of total gross returns; COW is the number of milk cows on the farm; AGE is the age in years of the principal farm operator; LAND is a dummy variable equal to one if the farmer had purchased land in the 1979–1984 period and zero otherwise; CTMA, VT, and NH are dummy variables indicating whether a farm is located in Connecticut or Massachusetts, Vermont, or New Hampshire. The excluded state

is Maine. Finally, EDUC1 and EDUC2 are dummy variables indicating the highest level of education attained by the farm operator. EDUC1 reflects more than 12 years but less than 16 years of schooling, EDUC2 reflects more than 16 years of schooling, and the omitted category is less than or equal to 12 years.

Production per cow and expense per cow are both endogenous variables; hence, their direct inclusion in the model would yield inconsistent parameter estimates. To avoid this problem, both of these variables are regressed on the corresponding 1983 values, and the forecasted 1984 values are used as instrumental variables for PROCOW and EXCOW. The second column of Table III presents the mean and standard deviation for the variables included in the logit model.

RESULTS

The logit model yields three intercepts (ALPHA1, ALPHA2, and ALPHA3) and three probabilities, $P1$, $P2$ and $P3$, which are defined as the probability that the farm is stressed or better, fair or better, or good, respectively. The probability that a farm is vulnerable ($P0$) is equal to 1-$P1$.

Likelihood ratio tests are performed to determine the importance of the state where the farm is located and of operator education on financial performance. The effect of each of these two groups of variables is tested by restricting the coefficients for each group, one at a time, to zero. The test statistic used is

$$-2\,[\ln(\hat{\Omega}) - \ln(\hat{W})]$$

where $\ln(\hat{\Omega})$ is the maximum value of the likelihood function without restrictions and $\ln(\hat{W})$ is the maximum value of this function subject to the restrictions.[18] Under the null hypothesis that the parameters of each group are equal to zero, this test statistic is distributed, asymptotically, as chi-squared with degrees of freedom equal to the number of restrictions.[19]

The results of the likelihood ratio tests indicate that education has no effect on financial performance. This finding is rather surprising given that education is often found to have an impact on managerial efficiency.[20,21] By contrast, the likelihood ratio test indicates that the state where the farm is located has a significant effect on financial performance. Farms located in Vermont are more likely to be in a better financial position than the rest of the farms in the sample. Given these results, the remainder of the discussion is based on the model that restricts the education parameters to zero.

Table III presents the coefficients, standard errors, and additional statistical information for the estimated models. The coefficients for PROCOW and MILKPRICE are positive, indicating that increases (decreases) in the values of these variables will increase (decrease) $P1$, $P2$, and $P3$. The coefficients for EXCOW and GRMPCT have negative signs, suggesting that increases (decreases) in the values of these variables will decrease (increase) $P1$, $P2$, and $P3$.

The relationship between $P1$, $P2$, $P3$, and COW has an inverted U-shape. This relationship shows that $P1$, $P2$ and $P3$ increase up to the point where COW is around 100 with further increases in COW having the opposite effect. A possible explanation for this finding is a U-shaped average cost curve for milk production which reaches its minimum point around 100 cows. By contrast, the relationship between $P1$, $P2$, $P3$, and AGE is U-shaped with a minimum point

Table III. Logistic Regression Estimates of Determinants of Financial Performance Position for a Sample of New England Dairy Farms—1984.

		Unrestricted Model	Restricted Model (w/o Educ.)	Restricted Model (w/o States)
Variable[a]	Mean [SD]	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)
ALPHA1	—	10.7732	10.1171	9.2879
		(7.1173)	(7.0284)	(6.7379)
ALPHA2	—	9.8513	9.1993	8.4703
		(7.1025)	(7.0129)	(6.7299)
ALPHA3	—	8.5356	7.8956	7.3215
		(7.0927)	(7.0061)	(6.7217)
PROCOW	14526.40	0.0008***	0.0008***	0.0007***
	[2375.05]	(0.0002)	(0.0002)	(0.0002)
EXCOW	1832.18	−0.0048***	−0.0047***	−0.0040***
	[388.75]	(0.0013)	(0.0013)	(0.0012)
MILKPRICE	13.94	0.4985**	0.5090**	0.2704
	[1.35]	(0.2286)	(0.2314)	(0.1923)
GRMPCT	0.94	−12.0643***	−11.9444***	−8.6785**
	[0.06]	(4.8224)	(4.8337)	(4.4400)
COW	65.93	0.0708**	0.0724**	0.0544**
	[33.38]	(0.0303)	(0.0300)	(0.0273)
COWSQ	5436.67	−0.0003***	−0.0004***	−0.0003**
	[6340.82]	(0.0001)	(0.0001)	(0.0001)
AGE	52.03	−0.3701*	−0.3616*	−0.2005
	[11.16]	(0.2142)	(0.2128)	(0.1925)
AGESQ	2830.90	0.0036*	0.0034*	0.0017
	[1120.99]	(0.0021)	(0.0021)	(0.0019)
LAND	0.13	−2.1430***	−2.2470***	−2.2386***
		(0.8280)	(0.7946)	(0.7749)
CTMA	0.08	1.1905	1.2462	
		(1.2064)	(1.1891)	
VT	0.66	2.3826***	2.2529***	
		(0.7563)	(0.7372)	
NH	0.10	−0.4005	−0.5102	
		(0.9709)	(0.9438)	
EDUC1	0.20	−0.2832		0.2412
		(0.7169)		(0.7047)
EDUC2	0.23	0.3631		0.2042
		(0.7936)		(0.6748)
McFadden R^2		0.28	0.28	0.19
−2 Log Likelihood		126.54	127.08	142.53
−2 Log Likelihood (Intercepts only)		175.57	175.57	175.57
Chi-squared		49.03	48.50	33.04
Degrees of Freedom		14	12	11

[a]For variable definitions see the text.

***Parameter significant at 0.01 level.

**Parameter significant at 0.05 level.

*Parameter significant at 0.10 level.

around 52 years of age. A plausible reason for this latter finding is that financial performance is weaker in the early years because the farm is growing; and, hence, debt loads tend to be high. As the farmer ages, farm expansion slows down, debt to asset ratios decrease and overall financial performance improves.

The dummy variable reflecting land purchases between 1979 and 1984 (LAND) has a negative coefficient, suggesting that the financial performance of farms that did purchase land during this period was adversely affected. The dummy variable for farms located in Vermont (VT) has a coefficient with a positive sign, indicating that a farmer in this state has a higher probability of being in the better financial categories than a farmer located in one of the other states in the sample. The coefficient for the dummy variable for farms located in Connecticut and Massachusetts (CTMA) also has a positive sign, but it is not significantly different from zero at conventional levels. Finally, the dummy variable for farms located in New Hampshire (NH) has a coefficient with a negative sign but, as was the case with the coefficient of CTMA, it is not significantly different from zero.

The validity of the model is assessed by using it to predict the probability of individual farms being in the various financial positions and then comparing these predictions to the actual classifications. The predicted probabilities are interpreted as follows: (a) a farm is predicted to be stressed if $P1$ is greater than 0.5, and $P2$, and $P3$ are both less than 0.5; (b) a farm is predicted to be fair if $P1$ and $P2$ are both greater than 0.5, and $P3$ is less than 0.5; (c) a farm is predicted to be good if $P1$, $P2$, and $P3$ are all greater than 0.5; and (d) the remaining farms are predicted to be vulnerable when $P1$, $P2$, and $P3$ are all less than 0.5. The model predicted 98 cases or 79% of the 124 farms correctly.

Table IV shows the marginal effect of a one unit change in each explanatory variable, using the restricted model (without education), on the financial performance probability holding all variables at their mean value. The marginal effects

Table IV. Predicted Marginal Probabilities of Financial Performance.

	Change in Probability[a]		
Variable[b]	$P1$	$P2$	$P3$
PROCOW	.00001	.00003	.00008
EXCOW	−.00006	−.00016	−.00048
MILKPRICE	.00699	.01679	.05188
GRMPCT	−.16399	−.39393	−1.21750
COW	.00034	.00082	.00253
AGE	−.00006	−.00015	−.00046
LAND	−.08040	−.17438	−.39140
CTMA	.04308	.09604	.22882
VT	.05476	.12420	.31730
NH	−.03697	−.07377	−.12498

[a] Probability of being stressed or better ($P1$), fair or better ($P2$), and good ($P3$). Marginal effects are calculated at mean values of the explanatory variables.

[b] For variable definition see the text.

for continuous variables are given by the partial derivative of the probability of financial performance ($P1$, $P2$, and $P3$) with respect to the given variable.[18] The partial derivatives are given by

$$\partial P_{ij}/\partial X_{ik} = B_k \exp(-Z)/[1 + \exp(-Z)]^2$$

The marginal effects associated with binary variables are equal to the difference in predicted probability when the variables are set first at one and then at zero.[22] The marginal effect for each binary variable is relative to the omitted category.

The marginal effects presented in Table IV show that increases in GRMPCT and LAND have a relatively large negative impact on $P1$, $P2$, and $P3$. Conversely, being located in Vermont versus Maine has a large positive impact on financial performance. A one unit change in PROCOW, EXCOW, MILKPRICE, COW, and AGE has a relatively small effect on $P1$, $P2$, and $P3$.

SUMMARY AND CONCLUSIONS

Multidimensional financial criteria were used to classify a sample of New England dairy farms according to their financial performance. The results of the financial classification provided a basis upon which to examine the determinants of financial performance using logit regression models.

Several conclusions can be drawn from the regression analysis which should have a bearing on operational decisions of dairy farmers. Deriving some farm income from sources other than milk sales and not purchasing land increased a farm's chances of being in a good financial position. To a lesser degree, a farm's chances of being in a good financial position would be enhanced if milk price and production per cow increase, operating expenses decrease, and herd size is around 100 cows.

Two other determinants identified in the analysis that have an influence on financial performance include being located in Vermont versus other New England states, and farms with operators less than or greater than age 52. Farms with these attributes have increased chances of being in good financial position. Finally, a surprising finding was that operator education was not a significant determinant of financial performance.

APPENDIX

Table A.I. Criteria Used for Classification of Dairy Farms by Financial Position[a]

If Debt/Asset Ratio Is	And If Return on Assets Is	And If Return on Equity Is	Then Financial Position Is
Operators with Equity under $50,000			
Under 40	Above 0	NA	Good
40 to 70	Above 5	NA	Good
Over 70	Above 15	NA	Good
Under 40	−5 to 0	NA	Fair
40 to 70	0 to 5	NA	Fair
Over 70	5 to 15	NA	Fair

(*continued*)

Table A.I.
(Continued)

If Debt/Asset Ratio Is	And If Return on Assets Is	And If Return on Equity Is	Then Financial Position Is
Under 40	−15 to −5	NA	Stressed
40 to 70	−5 to 0	NA	Stressed
Over 70	0 to 5	NA	Stressed
Under 40	Under −15	NA	Vulnerable
40 to 70	Under −5	NA	Vulnerable
Over 70	Under 0	NA	Vulnerable
Operators with Equity above $50,000			
Under 40	Above 0	Above 0	Good
40 to 70	Above 5	Above 5	Good
Over 70	Above 15	Above 15	Good
If Not Already Classified as Good, Then			
Under 10	Above −15	Above −15	Fair
10 to 40	Above −5	Above −5	Fair
40 to 70	Above 0	Above 0	Fair
Over 70	Above 5	Above 5	Fair
If Not Already Classified as Good or Fair, Then			
Under 10	NA	NA	Stressed
10 to 70	Above −15	Above −15	Stressed
40 to 70	Above −5	Above −5	Stressed
Over 70	Above 0	Above 0	Stressed
If Not Already Classified as Good, Fair, or Stressed, Then			Vulnerable

NA = Not Applicable.
[a]Criteria developed by Melichar[1] (p. 7).

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